BEFORE THE STATE OF WASHINGTON
ENERGY FACILITY SITE EVALUATION COUNCIL

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| IN RE APPLICATION NO. 96-1 | ) |
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| OLYMPIC PIPE LINE COMPANY: CROSS CASCADE PIPELINE PROJECT | ) |
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EXHIBIT _____ (SCW-T)

REBUTTAL TESTIMONY OF STEPHEN C. WILBUR, Ph.D.

ISSUE:

SPONSOR: OLYMPIC PIPE LINE COMPANY

**Q. State your name.**

A. Stephen C. Wilbur, Ph.D.
650 W. Georgia, #1900
Vancouver, BC

**Q. Where are you employed and what is your position?**

A. I am a Senior Geomorphologist/Hydrologist at Norecol Dames & Moore's Vancouver, BC office.

**Q. What subject area are you testifying on?**

A. Stream scour and channel migration.

**Q. Summarize your professional experience.**

A. I have 17 years of experience providing geomorphologic, geologic, hydrologic and hydrogeologic services throughout western North America. I worked on Trans Mountain's application for an oil pipeline permit proposed to cross rivers and creeks along a 150 mile corridor in the Puget Sound region. My work included review of all of the scour and lateral migration analyses performed for the project.

In addition to my doctoral research, I have previously been involved in the following projects involving erosion processes, including scour and lateral migrations: evaluation of the impacts to primarily salmonid resources from the removal of gravel from the Iskut River for use as backfill for the Eskay Creek Mine, BC; development of alternatives for the City of Portland and residents to restore the integrity of the Crystal Springs watershed; remedial investigation and feasibility study focused on improving water quality, enhancing fish habitat and reducing erosion potential for the Alumet Corporation's Holden Mine, Washington; geomorphologic, hydraulic and groundwater assessments to determine causes of flooding near Silver Lake, Kansas; supervises work elements regarding hydrologic data evaluation, geologic hazard ratings and development of GIS layers for the Seattle Water Department's Cedar River Watershed; hydrologic and stream channel evaluations of hydraulic geometry changes which causes erosion damages along the Tye River, Washington; hydrologic and geomorphic evaluation of hydraulic geometry changes due to channelization and meander cut-off causing erosion damage at the Raging River, Washington; evaluation of aggravating erosion and sedimentation at the Lewis Creek Watershed of King County, Washington; evaluation of coastal and fluvial dynamics of the Saganavirktok River on the North Slope of Alaska; evaluation of flooding of the Truckee River; development of surface and groundwater investigation for Ushk Bay Timber Harvest EIS, Tongass National Forest, Alaska; evaluation of the channel changes in the Issaquah River, Washington; inventory of landslide and erosion hazards for the City of Everett's development of their Sensitive Areas Ordinance; development of water quantity and quality baseline characteristics, and slope stability monitoring program required by SMCRA permitting process for the Usibelli Coal Mine in central Alaska; and performance of reconnaissance and ground surveys of areas undergoing high erosion on a corridor on the north side of the Alaska Range. for A more detailed outline of my experience is attached hereto as Exhibit SCW-1.

**Q. What is your educational background?**

A. I have a Ph.D. in Geology/Fluvial and Hillslope Geomorphology from the University of Alaska, Fairbanks, Alaska. My dissertation concentrated on quantifying sediment production (erosion) and sediment-transfer processes. I also have a M.S., Geology/Glaciology from the University of Alaska, Fairbanks, Alaska; B.A. Geology/Quaternary Studies/Ocean Resources from Humboldt State University, Arcata, California.

**Q. Have you published in your field?**

A. Yes. A list of my publications is included in my curricula vita.

**Q. To which prefiled testimony are you responding?**

A. Henry Landau § 2.5 (CCA); Susan Shaw (DNR); Terry Butler (King County DNR); Donald Finney (King County Development and Environmental Services); Douglas Pineo (Ecology); Randall Sandin (King County). I am also responding to the suggestion expressed in the Shapiro report § 2 (constructability of the pipeline) and repeated by Damien Hooper (Grant County) regarding further investigation of crossing in eastern Washington.

**Q. Beyond your professional qualifications and experience, what have you specifically done to prepare your testimony?**

A. I have reviewed the relevant sections of the Application and the DEIS, the prefiled testimony identified above, and the March 2, 1999, letter from Brian King to the Tulalip Tribes discussing crossing revisions and the Action Plan for the Tolt River Landslide Crossing. On March 15, 1999, I conducted a field reconnaissance from the North Fork of Cherry Creek to Mine Creek along the pipeline route. I also have familiarity with many of the stream crossings from my extensive work over the years in Washington State.

**Q. What is the difference between stream scour and channel migration?**

A. Both terms refer to erosion by a stream. Broadly speaking, **stream scour** refers to erosion of the channel bed (depth) and channel migration refers to horizontal changes of the channel within all or part of the floodplain (width). **Channel migration** occurs through several interrelated processes, including lateral migration (bank erosion), avulsion (typically a main channel shift involving more than one meander) and chute cut-offs (typically a main channel shift occurring within one meander).

**Q. How are these river processes evaluated in the course of planning projects like construction of a pipeline?**

A. These processes are evaluated by assessing the potential maximum depths of scour of the channel bed, and the potential extent of channel migration (width) within all or part of the floodplain. The depth of the pipeline burial is then designed to be below the maximum scour depth (plus a margin of safety), and beyond the reach of probable channel migration. In other words, data is collected to ensure that the pipeline design is beyond the reach of active vertical and horizontal stream processes.

**Q. What is the evaluation process for building the pipeline after a route has been selected?**

A. Evaluation of the stream crossing typically involves a multi-phased assessment. The first step is a screen of the crossings along the route to develop crossing methodologies and identify marginal and problem areas and present potential crossing solutions. Following approval of the project in principle, the next step is to analyze all of the stream crossings recognizing that the marginal and problem areas will require more in depth analysis to develop appropriate solutions and mitigation measures. Finally, the pipeline is designed to cross each stream, including the problem crossings, with an appropriate margin of safety (typically 2-4 feet below the maximum scour depth and beyond the reach of probable channel migration).

***Step one: the initial screen.***

**Q. What was involved in the initial screen?**

A. A number of things were done as part of the initial screen of the streams in the project area, for example: (a) scour potential was evaluated by West Consultants, Inc. (b) hydrologic sensitivity ratings were developed for each stream channel to evaluate the potential impact of construction and operation of the pipeline on the stream regime; and (c) stream channel forms and geomorphic characteristics were identified and classified to understand various construction and operational issues, environmental issues, and potential impacts associated with each stream channel form.

***a. West Consultant's scour potential evaluation***.

**Q. Let's start with the work done by West Consultants. How did they evaluate scour potential?**

A. West Consultants: (i) reviewed standard references and maps, reports and documents regarding the project area; (ii) collected stream-specific data necessary to assess stream scour; and (iii) reviewed aerial photographs to evaluate historical river channel patterns and identify floodplain sizes; (iv) conducted field reconnaissance of streams in the project area; and (v) used two empirically based models to estimate channel scour and identify crossings that needed further evaluation.

**Q. Would you briefly describe the two models used by West Consultants to screen for scour potential?**

A. The primary model was a method developed by Williams and others (1992) referred to as the "Threshold Drainage Area Method," and secondary method was developed by Blodgett (1985) of the USGS. Both models are empirical. In other words, they rely on mathematical formulas based on actual field, map, and climate data. The primary model calculates a threshold drainage area necessary to produce a 500-year return period flood capable of inducing an assumed scour depth for each crossing. The threshold drainage area calculation provides a mechanism for predicting potential scour for the 500-year return event. The primary model makes these calculations for five different assumed scour depths: 3, 6, 7, 8 and 10 feet. The results of  the calculations were used to identify areas that require further pre-design study at each of the assumed scour depths.  For example, according to West Consultant's results, if the pipeline is designed assuming a maximum scour depth of only 3 feet, then 30 crossings are identified as potential problem areas; while if the pipeline is designed assuming a maximum scour depth of 10 feet, then only 8 crossings are identified as potential problem areas.  As acknowledged by Mr. Landau, this method is recommended by the Bureau of Reclamation for design of structures such as a pipeline that are to be located in a river channel.

The secondary model, used to verify the findings of the primary model, calculates mean and maximum scour based on data from regression equations developed by USGS.  To build this model USGS measured scoured depths along large streams throughout the western United States, including Washington State.  Although the data collected for the USGS model is generally from streams larger than those in the project area, the predicted mean scour depths of the USGS model compared favorably to the findings of the primary method.

**Q. Mr. Landau expresses concern about ability of the primary empirical model to evaluate climate, terrain and hydrologic conditions associated with this particular project.  Is this a problem?**

A. No.  A strength of the primary model is the fact that the climatic, topographic (terrain) and hydrological data incorporated into the model were developed for each stream crossing along the pipeline.  Further, the regression equations used to develop this data were specific to the relevant regions within the State of Washington.

**Q. Mr. Landau also questions why West Consultants screen did not evaluate scour potential at culvert crossing, irrigation canals, bridge crossings, and six river crossings (Columbia River, Tolt River, Swauk, etc.). Is there an explanation for this?**

A. Yes. The purpose of the screen, including West Consultants scour analysis, was *not* to design the pipeline, but rather to develop sufficient information to define the scope of the project and specific locations that would require particularly extensive design. The crossings not included in the screen reflect these respective considerations. Specifically, culvert crossings will require specific design considerations to resist or eliminate scour, or prevent upstream and downstream channel erosion; the bed of an irrigation ditch is maintained at an uniform gradient and designed to prevent scour; bridge crossings that interfere with the river regime typically are locations of high scour potential and have had detailed technical assessments and will require more thorough analyses of the scour potential at the bridge abutments; and it was unnecessary to include the six river crossings in the screening analysis because it was self-evident that these crossing would require site-specific action plans (nonetheless, the screening calculations were completed for the Tolt and Sauk Rivers). As an illustration, the action plan for the Columbia River, a crossing long-recognized as requiring unique design, outlines a plan to horizontally directionally drill at depths far below scour; inclusion of this crossing in the screening analysis would have served no purpose.

**Q. Ms. Shaw comments that the West Consultants scour analysis does not address the potential impacts of back-filling the trench with a different mixture of sediment, or removing bed armor during trench digging. Are these legitimate concerns in reference to the West Consultant scour analysis?**

A. No. These are both construction issues, not issues that are relevant to the scour potential screening analysis performed by West Consultants. Nonetheless, West Consultants evaluated scour potential of the crossing based on watershed characteristics and conservatively assumed (*i.e.* smaller than the actual stream bed) sediment grain size characteristics.

Ms. Shaw is apparently concerned that the use of “clean gravel” discussed in the Application implies the importation of gravel from another remote source. Gravel of the appropriate size and contour is the preferred substrate on top of 1-foot of fill placed back in trenched spawning streambeds to reestablish spawning beds. To the extent possible, the native material excavated during the trenching process will be used in the general area to back-fill the trench. Further, in many cases screening (cleaning and sorting) of the excavated materials will be used to reconstruct the bed armor with appropriate grain sizes.

**Q. Ms. Shaw also contends that the West Consultant analysis is incomplete because it did not include field verification of the model prediction of scour potential at all crossings.**

A. In fact, West Consultants performed site visits as part of their analysis. Further, in March 1999, I performed a field reconnaissance of the stream crossings along a portion of the pipeline route. My field observations confirmed for example that Cherry Creek, Harris Creek (#22), and the Tolt River were properly designated as candidates for further study. As stated above, the West Consultants study is only a preliminary analysis which will be supplemented with detailed site-specific analysis, including detailed field assessments, for each crossing.

**Q. Ms. Shaw also criticizes the model because it does not specifically consider stream gradients. What is your response?**

A. The threshold drainage area model is a watershed-based model utilizing peak flow data for regions within the State of Washington. As such, the peak flow data for the Cascade region incorporates the intrinsic qualities of the stream hydrograph and channel geometry (depth, slope, width, velocity) for high gradient streams in the area. Although the model does not have stream gradient as a direct input, it is an implicit factor in the model derivation.

**Q. Mr. Pineo and Ms. Shaw apparently believe that only six streams will undergo further geomorphic and hydrologic study. Is that the case?**

A. No. Every stream crossing (except most irrigation ditches) will undergo further analyses and all sensitive crossings will at a minimum receive a detailed geomorphic and hydrologic study during the design phase.

***b. Site-specific channel analyses*.**

**Q. Was work done to evaluate channel erosion other than the scour analysis performed by West Consultants?**

A. Yes. For most of the crossings, hydrologic sensitivity ratings were developed. OPL Table 3.3-6 (Exhibit SCW-2). These ratings incorporated stream channel characteristics such as channel size, habitat quality, stream bed and bank erodibility, channel slope, bank steepness, rainfall, and occurrence of runoff and stream flows. The ratings were used to identify stream crossings that might require more field work during the design phase and might require specific construction methodology and stream mitigation best management practices (BMPs). Although these ratings have been largely ignored by critics of the project, they provide important data to evaluate the impact of the project on channel erosion.

*c. Identification and classification of stream channel forms and geomorphic characteristics.*

**Q. Mr. Landau, Ms. Shaw and Mr. Pineo contend that the Application fails to consider the special problems presented by geomorphic features such as alluvial fans and processes such as lateral migration and channel avulsion. Were these considered in the Application?**

A. Yes. Section 3.3 of the Application classifies stream channel forms OPL Table 3.3-5 (SCW-3). For example, with reference to alluvial fans, the Application provides a description of the channel conditions, identifies the geomorphic locations with a propensity to form alluvial fans, identifies important construction and operational issues associated with alluvial fans and describes the environmental issues and potential impacts during construction and operation. This section similarly addresses the impacts of the phenomena of channel shifting (avulsion and chute cut-offs). Further, during the next phase (step two), each crossing will be closely evaluated for potential problems presented by specific fluvial geomorphic processes.

**Q. Mr. Landau asserts that the use of FEMA defined floodplains misrepresent the risk of lateral migration. Does the applicant intend to rely solely on FEMA defined floodplains to design the project?**

A. No. FEMA provides the only publicly available source of floodplain maps, which accounts for why they were referenced in the Application. Obviously, the analysis of lateral migration for the project, however, does not depend on FEMA floodplain designations. Rather, the analysis according to standard practice considers aerial photographs, topographic maps and field work to evaluate the potential for channel migration within or beyond the FEMA designated 100-year floodplain.

**Q. The Shapiro report and Mr. Hooper contend that crossings in eastern Washington were overlooked. Was eastern Washington treated differently in the Application process?**

A. There was no difference in the analysis and presentation of data and information regarding each stream crossing based on which side of the mountains they are located.

***<u>Step two: analysis of all stream crossings to develop crossing solutions for scour related issues</u>.***

**Q. What is the next step if the pipeline project is approved?**

A. The data collected for the Application process will be supplemented with site-specific data. For instance, as part of the design process, site-specific geotechnical, hydrological, and geomorphologic analyses will be performed at all crossings of concern in the project to determine the potential scour for the 500-year event. The results will be used to classify the stream crossings. During construction of the pipeline, the classifications will be used to ensure that the pipeline is sufficiently below scour depth for the projected migration of the crossing. During this process, crossings like irrigation ditches will likely to be classified together because the pipeline at these crossings will have similar design feature, while crossing with unique geomorphic characteristics will be addressed individually.

**Q. What additional literature does OPL intend to review during this phase of the analysis?**

A. Any additional information identified during the application process. Moreover, for lateral erosion, OPL intends to review site-specific technical information prepared by professionals, including but not limited to the reports prepared by Perkins (1996) and Shannon & Wilson (1991). Preliminary analysis, however, indicates that this information is largely consistent with the data collected for the Application.

***<u>Step three: design of the pipeline</u>.***

**Q. How will data collected during the previous phase be used to design the pipeline?**

A. The data will be incorporated into a design document that sets forth the protocols for crossing each of the streams.

**Q. If the stream bed changes over time, especially after major storms, how will the pipeline be protected?**

A. During the design phase, maximum scour depth will be calculated for each individual crossing based on site-specific channel characteristics (e.g., including sediment caliber, channel gradient, hydraulic geometry, rate of base level change, channel stability) which govern both the short-term (seasonal peak discharges), and the long-term rates of channel migration and incision. Thus, for drainages of equal size, the calculated maximum scour depth will be greater for those streams that are now primarily downcutting as opposed to migrating.

**Q. Messrs. Landau and Nelson express concern about debris flows. How will the pipeline be designed to protect it from debris flows?**

A. Debris flows typically occur in steep-sloped terrain, within high gradient channels, and typically across alluvial fans. As the channel gradient decreases along the stream profile, the energy to transport debris decreases and sediment is deposited. In addition, depending on the flow energy and position along the profile, bed scour or bed aggradation can occur. Channels susceptible to debris flows, channel incision, bed aggradation and alluvial fan formation were addressed in Section 3.3 and summarized in Table 3.3-4 of the Application. Detailed channel-specific analyses that include an estimate of the potential for producing debris flows, and an estimate of bed scour in channels susceptible to carry debris flows will be incorporated and evaluated during the design phase.

**Q. Mr. Finney expresses concern that based on his experience buried pipelines have become exposed and required repairs or moved to a new location. Do the examples cited by Mr. Finney raise concerns that cannot be addressed.**

A. No. Notably, the two examples cites by Mr. Finney of pipeline exposures date back to 1983 and 1984. In the last 15 years, there have been significant advances in both the methodologies for assessing potential for stream bed and bank erosion and the technology for designing and constructing pipelines. The lack of any site-specific information regarding these incidents prevents evaluation of the specific cause of the pipeline exposure. However, it is likely that the root cause of these particular incidents (stream bed or bank erosion) is already being addressed during the design phase of the project.

**Q. Mr. Landau and Ms. Shaw express concern about the extent (width) to which the pipeline will be buried beneath the scour depth. How wide will the burial extend below scour depth on the stream crossings?**

A. The burial will be below maximum scour depth across the full width of the active channel and potential range of lateral migration. Depending on site-specific conditions, this will extend over all or part of the floodplain. For example, some floodplains (*e.g.* the Snoqualmie) are showing a long-term trend of aggradation which would have the effect of increasing the burial depth of the pipeline.

**Q. In addition to determining maximum scour depth will other safety factors be built into the design?**

A. Yes. There is a margin of safety below the estimated scour depth of at least 2-4 feet across the potential area of scour. Further, I understand, that under trenched stream crossings areas, the pipeline will be encased with concrete and thicker walled pipe used to protect the pipe from bed scour and flotation in the event of exposure.

***<u>Step four: construction of the pipeline</u>.***

**Q. What is the risk of sedimentation and increased stream turbidity arising from construction through trenching?**

A. The risk of sedimentation and increased stream turbidity arising from trenching will vary considerably based on the sediment load and channel characteristics at the stream crossing. In general, trenching in streams with a predominantly coarse load will have less risk of causing sedimentation and increased turbidity than work in streams with a large fine component. Accordingly, the chosen construction methods and mitigation measures will reflect these processes, such that streams with a predominantly fine-grained component will likely have more stringent requirements.

During the design phase, the proposed construction methods and mitigation measures will be reviewed to reflect the fact that sedimentation and stream turbidity are natural characteristics of the fluvial (stream or river) system that depend on local and basin-wide sediment load characteristics, and site-specific channel conditions. Sedimentation generally involves the deposition of the coarser part of the sediment load (e.g., sands and small gravels), while turbidity generally refers to that part of the load that stays in suspension during downstream transport (e.g., silts and clays). In general, sediment is transported or deposited based on stream velocity, which is a function of the channel gradient and stream discharge. In addition, the fluvial channel form (e.g., braided versus meandering) is due to variations in sediment load, stream discharge and channel gradient. In addition to the sediment load characteristics, site-specific channel conditions (e.g., remnant boulders too large to be transported by the present stream regime, bank vegetation, points of erosion or deposition, the presence of large woody debris in channel, etc.) will also affect the risk of sedimentation and increased turbidity. Recognition of these processes are alluded to in various sections that describe crossing methods and mitigation throughout the Application.

Absent mitigation or without proper mitigation, the risk of sedimentation and increased turbidity due to trenching is generally not long-lasting (i.e., the stream will re-stabilise even after the most invasive activity) but can be significant over the short-term (i.e., during construction and prior to re-stabilisation) for certain streams if the wrong method is used during the wrong time of year. The Application provides descriptions of mitigation measures to prevent sedimentation and turbidity from occurring and states that construction of stream crossings will be done during the least sensitive time of year.

**Q. What mitigation steps will be followed to reduce the risk of sedimentation and turbidity?**

A. The mitigation steps vary and will depend on the construction method (e.g., wet-trench, dry-trench, use of diversions or flumes, etc.), the time of construction (e.g., there is an ideal seasonal window for trenching), site-specific channel characteristics and habitat sensitivity. The Application describes trenching, material handling, backfilling, re-vegetation, bank stabilization, re-armoring and channel contouring plans to reduce the risk of sedimentation and turbidity. During the design and construction phases these plans will be further developed on a site-specific basis.

**Q. How will one evaluate whether mitigation is sufficient?**

A. Mitigation measures (along with a crossing method) will be determined based on site-specific field surveys conducted during the design phase. The channel and bed characteristics will be examined with respect to defining the risks of impacts associated with trenching as well as other associated risks (scour and channel migration, for example). In addition, field monitoring (e.g., for wet trenching, constant observation/oversight during trenching activities in combination with less frequent downstream field sampling of turbidity) of the trenching process will be conducted during construction to confirm that the mitigation steps are sufficient. Following construction, the crossings will be monitored to assure, for example, that re-vegetation, bank stabilization, and channel armoring plans are sufficient, or whether they require some modification.

**Q. Ms. Shaw expressed concerns about increased scour resulting from construction and mitigation measures (exhibit SCS-T, pages 57-61); specifically she was concerned about**

**disturbance of the armored layer and the loose packing that would result from backfilling the trenches. Is this a real concern?**

A. In general, these concerns are speculative and ignore the transient nature of the stream bed (i.e., the cut and fill dynamics during bedload transport and deposition). In addition, the trench width or affected corridor will only be about 1 meter, because in most cases the trackhoe will not operate in the stream bed.

The armour refers to the layer (or layers) of coarse grain sizes which form a resistant part of the stream bed. Commonly finer grains fill the interstices; the process of filling the interstices (or reducing porosity) is referred to as packing. Packing occurs during bedload deposition and also as flow velocities decrease and previously suspended particles fall down and into the coarser grains and work there way down between grains. In addition, packing implies that the armour is provided with decreased mobility because of the reduction in void space between the larger grains. Because of the coarse-grained nature, these grains are more difficult to move so that during decreasing flows and base flows (i.e., low flows fed by groundwater) only the finer-grains (i.e., silts and fine sands) exposed on the bed surface are entrained leaving only the coarse grains as armour. Thus, the fine grains below the armour are protected and the resultant transport of fines in the water column becomes negligible (i.e., reduced sedimentation and turbidity).

However, natural “packing” of stream sediments is generally loose and not compacted, and varies depending on the shapes of coarse grains and their degree of sorting or grading with the finer components of the sediment load. In certain hydraulic regimes, tabular or disc-shaped particles will tend to imbricate (i.e., overlapping cobbles or pebbles tilted in the same direction, with the flat sides dipping upstream), while round particles will not imbricate. Thus the potential for packing with finer grains varies with shape. Nevertheless, all shapes are sorted by stream energy, and sediments are referred to as being well, moderately or poorly sorted; these terms are generally equivalent to the engineers use of poorly, moderate and well graded, respectively (i.e., a poorly sorted deposit is well graded). Well-graded deposits (or engineered fill) are generally better packed (have less porosity); well-graded materials are used commonly to reduce settling (e.g., road bed material).

The most important fundamental concept regarding the armour and packing quality is to recognise its degree of transiency. The characteristics of the armour are dynamic and reflect the temporal nature of the stream and channel form. The "packed" armour reforms after large discharge events which are capable of entraining the coarse material. Also, the location of armouring (and degree of packing) varies and is dependent on the sediment load characteristics and the processes of channel migration and aggradation. In some cases, the armour developed after a small storm will be wiped out and replaced by coarser armour following a large summer storm. Mitigation measures will consider this process and the re-constructed armour will be comprised primarily of the largest sizes of boulders and cobbles found in the channel. Thus, after consideration for the depth of scour, the natural cut and fill dynamics will be left intact. In some cases the armour may consist of boulders exhumed from older stream terraces or deposits constructed during times of higher flow regime (e.g., glaciofluvial) and the existing stream cannot entrain (or scour) through the armour, even during exceptional flows. This armour will be replaced with the large boulders. However, in other cases, the sediment load is predominantly fine and re-constructing the armour is not as critical because of the highly transient nature of the bedload.

The trench backfill material (under the armour) will generally be well-graded and equal to or coarser than the site-specific channel sediment load, and the armour will be replaced with comparable-sized material, thus there is no increased risk due to the trench re-filling techniques. Packing will be a natural component of the graded materials.

DATED this ___ day of March, 1999.

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Stephen C. Wilbur